

## Fuel Cells – the Electrochemical Solution to Power Generation in the 21<sup>st</sup> Century An Industrial Development Perspective

Stephen L. Kukucha

Ballard Power Systems  
9000 Glenlyon Parkway, Burnaby, B.C., V5J 5J9, Canada

Once the exclusive domain of scientists, futurists and science fiction writers, fuel cells are now being utilized in a wide variety of power generation applications including portable, stationary and transportation uses. Driven by the quest for reduced levels of harmful emissions, energy security and diversity concerns, greater efficiency and industrial development opportunities, both government and industry have continued to invest heavily in research, development, commercialization and manufacturing activities involving fuel cell technology.

Because of this investment, dramatic progress has been made including improved reliability, performance (including power density), cost reductions and manufacturing improvements for all fuel cell applications. Generally, this investment has been driven by the factors as outlined above. However, both investment and progress have been accelerated by specific legislative and policy initiatives to improve air quality, reduce emissions and increase energy security and diversity. Further, strategic government investments to stimulate the development of fuel cells (and/or enabling technologies), demonstrate fuel cell products and develop and demonstrate fueling infrastructure have also been greatly beneficial. While continuous improvement will occur as the technology matures, much like the internal combustion engine has developed over the last 100 years, fuel cells are ready to become commercially viable solutions to provide clean and efficient generation capacity over a broad spectrum of product applications.

With the current level of technology development and the broader acceptance fuel cells are receiving (because of high profile demonstrations and the move to find cleaner, alternative generation capacity) the next few years will see a wide array of fuel cell products being commercialized. As an example, Ballard is targeting to commercialize portable power generation units in 2001, fuel cell buses in 2002, stationary power products in 2003 and automotive fuel cells in 2004-2005.

The case for the continued development, commercialization and market adoption of fuel cell products is clear. Fuel cell products embody an enabling technology that provides a unique value proposition for customers, and a distinct advantages over current power generation products, because they are zero (or near zero) emission, utilize divergent fuel feedstock (both carbon based and renewable), are scalable and provide flexibility in power generation. Further, the proliferation of fuel cell products will provide a solution to reduce both greenhouse gases (and global warming) and toxic local emissions.

Fuel cells are a simple, cost-effective and elegant technology that will be a major part of the overall solution to the power generation dilemma facing the world today. As worldwide power consumption increases, both governments and society are becoming increasingly aware of the urgent need to seek more environmentally sustainable power generation products. Given this compelling policy rationale, governments have an increasingly critical role to play in facilitating the market introduction of products that embody a more environmentally sound technology.

While fuel cell products are not a “silver bullet” solution to either air quality concerns or climate change issues, they allow governments to achieve both of these objectives while also pursuing an energy policy that is more environmentally sustainable. Fuel cell products are a key pillar (along with the pursuit of renewable sources of energy and conservation) in any sustainable energy policy because their unique attributes (improved efficiency, fuel neutrality and reduced emissions) will enable the energy sector to transition to a more sustainable path which includes strategies for zero emission fossil fuels and renewables. While it is generally accepted that fuel cells powered by hydrogen produced from renewables, and/or zero-emission fossil fuel technology, are the optimal solution for the future, the transition to this scenario is uncertain and potentially disruptive to both the economy and existing stakeholders. Fuel cell products can help limit the disruptive nature of this transition by providing a technology solution bridging the gap between fossil fuels and renewables.

However, because of the uncertainty in the path to a reduced emission fuel cycle, and the fact that fossil fuels will remain a part of energy policy in the foreseeable future, government must play a role by supporting and investing in enabling technology solutions such as fuel cells (and other enabling technologies such as carbon sequestration). While government support of fuel cell products will enable emission reductions from the fuel cycle, government can also utilize the tools at their disposal (policy, legislative and spending) to play a role in addressing cradle to grave emissions from fuel cell products (including the reduction of emissions from extracting precious metals and the manufacturing processes for fuel cell). If government successfully supports these transitions to reduced emissions, the benefits to society will be both environmental (as outlined above) and economic because industrial benefits (including industrial development, job creation, and industrial diversification) will also flow from the proliferation of fuel cell technology and products.

However, the wide range of benefits that fuel cells can provide to society will only be realized if consumers and the “market” adopt the products based on this technology. Government also has a critical role to ensure that process is accelerated. While consumer acceptance will primarily be driven by cost and reliability considerations, government can facilitate this process by easing the market entry of the fuel cell products through targeted policy and legislative initiatives along with strategic spending initiatives (both of which will continue to leverage significant private sector investment).

From a policy and legislative perspective, governments must continue to strive for improved air quality, reductions of green house gases and the removal of barriers to the introduction of fuel cell products. While we are mindful that economic considerations are often foremost in the minds of government constituents, we believe government will come under increasing pressure to address air quality and climate change as the health consequences of toxic air and increased global warming continue to escalate. To address these policy objectives, government has a number of tools at their disposal such as regulating more stringent requirements to limit emissions of both local pollutants and green house gases (including zero emission mandates for buses and cars). Governments can also create incentives to the adoption of fuel cell products by offering tax credits, purchasing fuel cell products, providing preferred access for fuel cell products, streamlining regulatory approvals and other innovative solutions that will increase consumer demand. Other government activity can include providing a favorable and collaborative climate for the development and coordination of codes and standards (in North America and globally), analyzing life cycle emission impacts of fuel cell products, supporting training initiatives for fuel cell technology, introducing an emissions trading system to incentivize fuel cell products and punishing polluters by instituting environmentally based taxation policies. Through all of these activities, governments can contribute significantly to a healthier environment for all their constituents

From a strategic spending perspective, it is important for government to make a consistent, long-term commitment to fund the fuel cell industry. Continued investment needs to be made, in collaboration with industry, in both fuel cell and enabling technologies in order to close technology gaps that could slow the commercial introduction of fuel cell products. However, it will be crucial for governments (within North America and globally) to collaborate with industry (and each other) in order to avoid squandering scarce resources by duplicating efforts (instead of leveraging existing expertise within this maturing industry). There are several key areas where government can make an impact and accelerate the development of fuel cell technology including: more focused work on fuel reforming (while avoiding overlap), increased emphasis on hydrogen storage and hydrogen generation, an increased focus on the establishment and development of testing standards, the evaluation of materials recycling (both practical applications and modelling studies), analysis of the value of high temperature PEM fuel cells, investment in other enabling technologies including compressors and control systems and more focussed collaboration with industry on fuel cell testing (to focus on core scientific questions that will benefit all fuel cell companies).

As well, continued investment needs to be made to raise the profile and visibility of fuel cell technology through product demonstrations and outreach and education activities. These investments will be critical to raise consumer awareness, educate society about the benefits of fuel cell products (and allay any concerns they may have regarding the technology) and drive demand from individual consumers as well as industrial and government customers. Specifically, investments in demonstrating fuel cells in buses, cars and other applications will ensure barriers are removed, codes and standards are developed, demand is driven and enabling fuel infrastructure is developed. Finally, government continues to have a role to play in facilitating cooperation amongst key

industrial players where it is warranted and where the activity can not be considered to be anti-competitive or collusive (including activities like the California Fuel Cell Partnership, codes and standards activities and some fuel infrastructure development).

For a fuel cell developer, there continue to be a number of opportunities and challenges on the path to successful commercialization. Fuel cell companies will continue to reduce costs, prepare for volume manufacturing, participate in the establishment of international codes and standards, improve the power life cycle (cradle to grave) and encourage the development of an alternative fuel infrastructure. At the same time, we must also work to prepare consumers and existing manufacturers for the commercial introduction of this potentially disruptive technology. These tasks and the benefits that will be derived from a successful commercialization of the technology can be achieved by industry but government continues to have a critical role in accelerating this process.

Leadership by government will ensure future generations stand to benefit from the accelerated introduction of fuel cell products into initial target markets, which in themselves only represent the tip of the iceberg. The extent to which fuel cell technology and the products derived there from will benefit society will become apparent only with time. There is a growing recognition though, among corporations, governments and individuals, that fuel cell technology represents the power to change the world.